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Estimation of Cod, Haddock and Yellowtail Flounder Discards from the Canadian Georges Bank Scallop Fishery for 1960 to 2004

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ABSTRACT

Cod, haddock and yellowtail flounder discards from the Canadian scallop fishery on Georges Bank were estimated for 1960 to 2004 from 9 observed trips in 1991, 1994, 1995 and 1998, 12 observed trips in 2001 and 2002 and 5 observed trips in 2004. Data were insufficient to determine spatial differences but temporal (quarterly) trends were detected for all three species. The analysis was split into 2 periods, 1996 to 2004 when landing of groundfish was not permitted and 1960 to 1995, when groundfish landings were allowed for this fishery. Three approaches were used to estimate discards. Ratios of groundfish discards to landed groundfish, scallop effort and landed scallop were determined from observed trips and applied to annual landed groundfish, scallop fishery effort and landed scallop for 1960 to 1995. For the period 1996 to 2004, a discard to scallop effort ratio was determined from available data and quarterly ratios incorporating a seasonal pattern were interpolated from these for periods when no observed trips were available. Resultant discard rates were then applied to the total quarterly effort of the scallop fleet. Discard rates were highest for yellowtail flounder and cod while those for haddock were substantially lower.

RÉSUMÉ

Nous avons estimé, pour la période 1960-2004, les rejets de morue, d'aiglefin et de limande à queue jaune dans les pêches canadiennes des pétoncles sur le banc Georges à partir des données recueillies dans le cadre de 9 sorties assujetties à observation en 1991, 1994, 1995 et 1998, de 12 telles sorties en 2001 et 2002 et de 5 autres en 2004. L'insuffisance des données n'a pas permis d'établir si les rejets variaient en fonction du lieu, mais des tendances temporelles (trimestre) ont été dégagées pour les trois espèces. L'analyse est divisée en deux périodes : 1996-2004, lorsqu'il était interdit de débarquer du poisson de fond capturé dans le cadre de la pêche des pétoncles, et 1960-1995, lorsque cela était permis. Nous avons utilisé trois facteurs, que nous avons établis à partir des données sur les sorties assujetties à observation puis appliqués aux débarquements annuels de poisson de fond, à l'effort de pêche des pétoncles et aux débarquements de pétoncles de 1960 à 1995, pour estimer les rejets : la proportion de rejets de poisson de fond par rapport aux débarquements de poisson de fond, l'effort de pêche des pétoncles et les débarquements de pétoncles. Pour la période 1996-2004, nous avons établi les proportions de rejets par rapport à l'effort de pêche des pétoncles à partir des données disponibles, puis nous avons interpolé les proportions trimestrielles incorporant une tendance saisonnière à partir de celles-ci pour les périodes pour lesquelles aucune sortie n'a été assujettie à observation. Nous avons ensuite appliqué les taux de rejet ainsi obtenus à l'effort total trimestriel de la flottille de pétoncliers. La morue et la limande à queue jaune ont connu les taux de rejet les plus élevés, alors que le taux était nettement moins élevé pour l'aiglefin.

INTRODUCTION

The Canadian scallop fishery on Georges Bank is considered one of the principal sources of groundfish discards. Discards due to the Canadian scallop fishery have not previously been included in assessments of eastern Georges Bank cod and haddock or of Georges Bank yellowtail flounder. Results from at-sea observer monitoring in 2001-2002, indicated discards of cod, haddock and yellowtail flounder were considerable relative to current landings. To conduct a meaningful assessment of groundfish stock status, the inclusion of discards as part of the total removals must be consistent over the entire time series. Discards cannot be included in some years and left out in others. The purpose of this paper was to estimate the discards of cod, haddock and yellowtail flounder from the Canadian scallop fishery on Georges Bank for 1960-2004.

Prior to 1996, landing of groundfish by-catch by the Canadian scallop fishery on Georges Bank was permitted. However, it is generally acknowledged that all the groundfish by-catch was not landed. To account for the total by-catch, it is necessary therefore to augment the landings by the scallop fishery with the discarded amounts of by-catch. Management measures established in 1996 prohibited the landing of groundfish (except monkfish) by the Canadian scallop fishery. All by-catch of cod, haddock and yellowtail flounder was therefore discarded. Discards, whether pre or post 1996, were not recorded in the scallop fishery statistics.

Discards can be estimated from information collected by at sea observer deployments. Few scallop fishery trips have had observer coverage (Table 1). Nine trips conducted in 1991, 1994, 1995 and 1998 were monitored (Figure 1). In response to a Fisheries Resource Conservation Council recommendation, a monitoring program was conducted by the Canadian offshore scallop industry in 2001 and 2002 to gather data on by-catches. Twelve trips were observed which covered all months except January and October (Figure 2). Starting in August 2004, routine observer deployment on vessels participating in the Canadian scallop fishery on Georges Bank was initiated. Five trips were observed in 2004 (Figure 3).

Data and Methods

Incidental catch of groundfish in the Georges Bank scallop fishery will be referred to as "by-catch". By-catch may be landed. "Landed" refers only to that portion of the catch that is recorded in the fishery statistics records. Any by-catch that is not landed will be designated as "discards". Unless otherwise specified, the terms discard and landed are used to refer to the by-catch species of interest.

Three approaches to estimating discards of by-catch species in the scallop fisheries on Georges Bank were considered. All three approaches involve pro-rating observed discards by a total to observed ratio of some other quantity.

Approach A: *discard / landed = observed discard / observed landed*
giving *discard = observed discard (landed / observed landed)*

Approach B: *discard / scallop effort = observed discard / observed scallop effort*
giving *discard = observed discard (scallop effort / observed scallop effort)*

Approach C: *discard / landed scallop = observed discard / observed landed scallop*
giving *discard = observed discard (landed scallop / observed landed scallop)*

Approach A is dependent on the assumption that discarding practices, i.e. the (*discard / landed*) ratio for observed scallop fishing, is representative of discarding practices for the scallop fishery. Approach B is dependent on the assumption that the by-catch population density, i.e. the (*discard+landed / scallop effort*) ratio for observed scallop fishing, is representative of that for the scallop fishery as well as on the assumption that discarding practices are representative. Approach C is dependent on the assumption that the relative population density of the by-catch species to the population density of scallop, i.e. the (*discard+landed / scallop discard+landed*) ratio for observed scallop fishing, is representative of that for the scallop fishery as well as on the assumption that discarding practices are representative. Further, because we only have information on the landed scallop catch, and some of the scallop catch is culled, this approach also depends on the assumption that discarding practices for scallop during observed scallop fishing is representative of that for the scallop fishery.

When sampling intensity is high and a large proportion of the scallop fishing is observed, all three approaches may give reliable results. The variability of the respective ratios used in approaches A, B and C influences how much observed sampling is required to obtain a representative view of the fishery. Population density generally varies by location and over seasons and years, while discarding practices may be more stable. Approach C is sensitive to variation in the population density of the by-catch species, to variation in the population density of scallop and to variation in discarding practices for scallop. Approach B is sensitive to variation in the population density of the by-catch species. Approach A is only sensitive to variation in discarding practices for the by-catch species. However, Approach A can only be applied in situations where landing of the by-catch species is permitted. When there are no landings of the by-catch species or when landings are very low, only Approaches B or C can be considered. It can be postulated therefore, that, when the requisite information is available, Approach B should be favoured over Approach C and that Approach A might be favoured over both Approaches B and C. These considerations are particularly important when the sampling intensity is low and only a small proportion of the scallop fishing is observed, as the observed ratios used for pro-rating need to be applicable over broader spatial and temporal domains.

The analysis was done separately for two periods. The period 1996-2004, when landing of cod, haddock and yellowtail flounder was not permitted, was considered first because there was higher observer coverage. The period 1960-1995, when landing of cod, haddock and yellowtail flounder was permitted, is based on very limited observer coverage.

Results and Conclusions

Discard Estimates for 1996 to 2004

Since landing of cod, haddock and yellowtail flounder was not permitted during this period, Approach B was applied to estimate discards. For this approach the observed trips for 1995, 1998, 2001, 2002 and 2004 were used to evaluate the discard to scallop effort ratio. The 1995 trips were included to permit interpolation for 1996 and 1997, as described below. To make 1995 comparable to trips where landing was not permitted, the sum of observed discards and kept was used as the by-catch.

Effort refers to hours towed, with usually 2 dredges being towed at the same time. As there is no adjustment for amount of gear in either number of dredges or size of dredges, it is assumed that the amount of gear used on observed trips is representative of the amount of gear used in typical operations. Effort information may be obtained from observer records or from fishery statistics. Since the fleet effort must be obtained from fishery statistics, it was considered preferable to use the effort from fishery statistics for the observed trips as well, to ensure consistency. However, this was not always possible and observed effort was derived for those cases.

Several observed trips for 1995 and 1998 were industry initiatives to evaluate modifications to standard scallop gear. When modified gear was used, it was usually towed along with the standard dredge as a control. In these instances, only catch from the standard scallop dredge configuration was used. The corresponding effort data could not be obtained from fishery statistics. For these trips the effort was obtained from observer records. In the instances where modified gear was used, the observed effort hours were halved to be equivalent to a standard industry tow where two dredges are usually towed together. As a check on the equivalency of the observed effort and fishery statistics effort, for a few trips where it was possible, the observed effort was pro-rated to the entire trip. The pro-rated effort compared favourably with the fishery statistics effort, 143 versus 143 for trip T1995-1, 128 versus 127 hours for trip T1995-3 and 141 versus 132 for trip T1998-1. Trip effort for the 2001, 2002 and 2004 observed trips was obtained from fishery statistics (pers. com. Dr. Ginette Robert, DFO).

The fishery statistics effort represents the hours fished for the entire observed trip. It is necessary therefore to prorate the observed discards to the discards for the entire observed trip. For trips in 1991-1998, observed effort hours were recorded. For these trips the proration factor was the ratio of observed to trip effort hours. For trips in 2001 and later, observed effort hours were not recorded. In the absence of effort hours, pro-ration would preferably be done using the ratio of total tows to observed tows, but observer data was not recorded by tow either. For trips in 2001 and later, observers were instructed to group tows into "sets" of roughly 3 hours or more during which several tows were usually carried out. All catch data was recorded by "set". The number of dredges towed during a "set" was also recorded, but number of tows was not. The total discards for the trip was obtained by prorating the observed discards by the ratio of total number of dredges to observed number of dredges recorded for the trip. This was considered more accurate than using the ratio of total sets to observed "sets" since the number of tows and dredges in a set varied considerably.

Area specific effort from fishery statistics usually corresponded with the area designations by observers. However one observed trip, T2001-3, showed that sets had occurred in both unit areas 5Zj and 5Zm whereas effort from fishery statistics was supplied for unit area 5Zj only. Total effort for this trip was split between the two unit areas according to the number of dredges towed in each area from observer records.

Both temporal and spatial patterns in discard rates (sum of discards per quarter divided by sum of effort per quarter) might be expected, but there were not enough observed trips in 2001 and 2002 to calculate discard rates for each quarter and area as 5Zm had observed trips only in April, June, July and August (Figure 2). Trips observed between 1991 to 1998 were also not suitable for investigating spatial patterns (Figure 1). Available data therefore, do not support any unit area patterns in discard rates for cod, haddock and yellowtail flounder (Fig. 4). There appeared to be temporal patterns for all 3

species. A tendency for higher discard rates of yellowtail flounder in quarter 2 and lower discard rates in quarter 4 were evident (Fig. 4). Cod and haddock exhibited similar patterns with higher rates occurring in quarters 1 and 4 and reduced rates in quarters 2 and 3. The cod and haddock spawning aggregations that occur on the bank in winter and spring coincide with the higher catch rates at this time of the year. While the dispersion of observations was great, these results were generally consistent with seasonal patterns of discard rates for 2004 and of landings per unit of effort (trip) observed during 1986-1995 (Figure 5). The landings patterns were very similar for yellowtail flounder but were somewhat different for haddock in quarter 4 and cod in quarter 2, although more similar to the pattern observed for cod in 5Zj alone (Figure 4). The discard rates from observed trips in 2001-2002 and in 2004 were aggregated to obtain seasonal factors (Figure 6). The proration was conducted using discard rate by quarters (Table 2). Trip T2002-3 from April 2002 was pooled with the other trips in the second quarter of 2001 to increase sample size.

Quarterly discard rates for periods when no observed trips were available were derived by interpolation and application of a seasonal pattern (Figure 7). To estimate discards for year 1996 and later, the quarterly discard rates were applied to the total quarterly effort of the scallop fleet (Table 3).

Discard Estimates for 1960-1995

For this period when landings of cod, haddock and yellowtail flounder were allowed, Approach A which uses the ratio of discards to landings might have been preferred. However, the number of observed trips in this period was very limited and the ratios subject to the influence of anomalous outliers. Therefore results from all three approaches were compared and the results from the approach that gave the most reasonable values were used as the discard estimates.

The observed kept amount appears to include fish that were retained but not subsequently sold and recorded in the fishery statistics ("prorated kept" versus "landed" (Table 4)). This may reflect the practice of using "crew shares" as partial compensation or in the case of yellowtail flounder reporting it as another species. The zero yellowtail flounder landings reported for trip T1995-4 when 792 kg were observed kept (Table 1) is likely a result of reporting all the flounder caught for that trip as winter flounder. This trip was not used for calculating discard rates for yellowtail flounder. Assuming that the observed kept for trips T1994-1 and T1995-3 were landed, the observed kept from the other trips, which did not report any landed cod, haddock or yellowtail flounder, was prorated to the trip and added to the discards to derive an overall ratio of discard to landed, excluding trip T1995-4 for yellowtail flounder (Table 4). The resulting discard to landed ratio for yellowtail flounder was 3.74 (i.e. (7.484 mt + 0.138 mt) /2.038 mt). Similarly for cod and haddock, the discard to landed ratios were 0.681 for cod and 4.582 for haddock.

To obtain the discard to effort ratio needed for Approach B, the sum of the prorated kept for trips which did not report any landed by-catch were added to the sum of prorated discards, (excluding trip T1995-4 for yellowtail flounder), and divided by the sum of effort (Table 4). The resulting discard rate was 6.873 kg/h (i.e. (7.484 mt + 0.138 mt) /1109 hr) for yellowtail flounder, 0.978 kg/h for cod and 1.774 kg/h for haddock (Table 4). These by-catch rates are within the range of the observed quarterly discard rates in 2001-2004 for yellowtail flounder and haddock but low for cod.

Finally, the discard to landed scallop ratio needed for Approach C was derived in a similar manner, i.e. sum of prorated discards plus prorated kept for non-reporting trips divided by the scallop landings. The resulting discard to landed scallop ratio was 0.0115 (i.e. (7.484 mt + 0.138 mt)/660.384 mt) for yellowtail flounder, 0.0019 for cod and 0.0034 for haddock (Table 4). In comparison to the haddock ratio, the cod ratio seems low when contrasted with the 2001-2004 trend.

Resulting discards for 1960-1995 using each of the three approaches are summarized in Table 5 along with the discard estimates for 1996-2004. Scallop fishery effort was not available prior to 1972 and groundfish landings from the scallop fishery were unavailable prior to 1968 so not all approaches could be compared for all years. The discard estimates based on the discard to landed ratio do not appear consistent with the amount of effort and almost certainly underestimated the discard amounts. The discard estimates based on discard to effort ratio and discard to landed scallop ratio are fairly comparable. The landed scallop proration appears somewhat susceptible to variation in scallop abundance. For example, when effort remained high and yellowtail abundance was thought not to be changing much, estimated discards vary more than expected. Estimated discards also do not follow known abundance trends of by-catch species, due, no doubt, to the paucity of observer data used to calculate discard ratios.

In conclusion, the effort proration results appear most reasonable of the three approaches and were used in the stock assessments for the three species for 1972 to 1995. When scallop effort was unavailable, i.e. prior to 1972, the proration using scallop landings appears to be the next most reliable estimation. The proration methodology was reviewed during the framework review of the Georges Bank yellowtail flounder assessment in 2005 and was deemed acceptable.

Table 1. Observed trips from the Canadian Georges Bank scallop fishery.

		Effort (h)		Dredges			Yellowtail Flounder (mt)				Cod (mt)				Haddock (mt)				Scallop
Trip ID	Date	Trip[1]	Obs.	Trip	Obs.	Pro.[2]	Obs. Dis.	Prorated Dis.	Obs. Kept	Landed[3]	Obs. Dis.	Prorated Dis.	Obs. Kept	Landed[3]	Obs. Dis.	Prorated Dis.	Obs. Kept	Landed[3]	Landed (mt)[3]
T1991-1[4]	Jan '91	348	176			0.50	2.568	5.086	0	0	0.267	0.529	0.037	0	0.007	0.014	0.687	0	167.896
T1994-1	Mar '94	138	116			0.84	0.060	0.071	0.363	1.738	0.003	0.004	0.154	0.341	0	0	0.050	0.033	127.501
T1994-2	Mar '94	127	97			0.77	0.001	0.001	0.060	0	0	0	0.136	0.531	0	0	0.068	0	114.237
T1994-3	Mar '94	106	75			0.71	0.219	0.311	0.024	0	0.051	0.072	0.025	0.000	0.005	0.007	0.074	0	69.013
T1995-1[4]	Jan '95	143	33			0.23	0.079	0.338	0.006	0	0.034	0.145	0.055	0.090	0.024	0.103	0.074	0	60.867
T1995-2[4]	Mar '95	120	11			0.09	0.04	0.447	0	0	0.029	0.324	0.023	0.176	0.005	0.056	0	0	49.440
T1995-3[4]	Mar '95	127	21			0.16	0.199	1.230	0.028	0.3	0.010	0.062	0.075	0.690	0.005	0.031	0.122	0.460	71.430
T1995-4	Mar '95	164	91			0.56	0.311	0.558	0.792	0	0	0	0.045	0.407	0	0	0.099	0	78.243
T1998-1[4]	June '98	132	32			0.25	0.811	3.301			0.041	0.167			0.030	0.122			91.476
T2001-1	May '01	33		130	88	0.68	0.957	1.414			0.324	0.479			0.028	0.041			153.862
T2001-2	June '01	124		466	372	0.80	1.753	2.196			0.071	0.089			0.006	0.008			166.772
T2001-3	July '01	125		457	357	0.78	1.902	2.435			0.254	0.325			0.020	0.026			134.386
T2001-4	Aug '01	108		264	181	0.69	1.693	2.469			0.039	0.057			0.003	0.004			143.132
T2001-5	Aug '01	68		254	196	0.77	0.523	0.678			0.184	0.238			0.012	0.016			160.136
T2001-6	Sep '01	47		178	133	0.75	0.830	1.111	Landing of yellowtail flounder not permitted		0.068	0.091	Landing of cod not permitted		0.004	0.005	Landing of haddock not permitted		166.225
T2001-7	Nov '01	16		126	86	0.68	0.005	0.007			0.071	0.104			0.061	0.089			139.156
T2001-8	Dec '01	33		147	115	0.78	0.045	0.058			0.147	0.188			0.042	0.054			116.014
T2002-1	Feb '02	43		297	217	0.73	0.219	0.300			0.195	0.267			0.084	0.115			144.119
T2002-2	Mar '02	39		122	92	0.75	0.711	0.943			0.195	0.259			0.025	0.033			122.866
T2002-3	Apr '02	120		334	212	0.63	3.867	6.092			0.198	0.312			0.088	0.139			139.740
T2004-1	Aug '04	265		1584	790	0.50	1.395	2.797			0.432	0.866			0.167	0.335			171.610
T2004-2	Sep '04	105		600	308	0.51	0.298	0.581			0.05	0.097			0.047	0.092			71.822
T2004-3	Oct '04	74		326	164	0.50	0.063	0.125			0.009	0.018			0.021	0.042			53.190
T2004-4	Nov '04	334		1645	858	0.52	0.352	0.675			1.303	2.498			1.138	2.182			380.860
T2004-5	Dec '04	191		712	364	0.51	0.209	0.410			0.124	0.242			0.056	0.110			130.324

[1]Trip effort for 2001-2004, pers. com G. Robert, Fisheries and Oceans Canada

[2]Proration based on ratio of effort for 1991-1998 and on ratio of dredges for 2001-2004, used to prorate discards.

[3]Landings from reported fishery statistics.

[4]Modified dredges used on these trips, observed effort, discards and kept are for standard gear only.

Table 2. By-catch rates from observed trips in 1995, 1998, 2001, 2002 and 2004.

			Yellowtail Fl. (mt)		Cod (mt)		Haddock (mt)			By-catch rate (kg/h)		
Trip ID	Month_YR	Proration	Obs.	Pro-rated	Obs.	Pro-rated	Obs.	Pro-rated	Effort (h)	Yellowtail Fl.	Cod	Haddock
T1995-1	Jan_95	0.23	0.085	0.363	0.089	0.387	0.098	0.419	143	2.542	2.661	2.931
T1995-2	Mar_95	0.09	0.040	0.447	0.052	0.578	0.005	0.056	120	3.721	4.837	0.465
T1995-3	Mar_95	0.16	0.227	1.404	0.085	0.531	0.127	0.785	127	11.052	4.138	6.183
T1995-4	Mar_95	0.56	1.103	1.980	0.045	0.080	0.099	0.178	164	12.076	0.493	1.084
	1995 Q1			**4.194**		**1.567**		**1.438**	**554**	**7.570**	**2.829**	**2.595**
T1998-1	Jun_98	0.25	0.811	3.301	0.041	0.167	0.030	0.122	132	25.008	1.264	0.925
	1998 Q2			**3.301**		**1.576**		**0.122**	**132**	**25.008**	**1.264**	**0.925**
T2002-3[1]	Apr_02	0.63	3.867	6.092	0.198	0.312	0.088	0.139	120	50.770	2.600	1.155
T2001-1	May_01	0.68	0.957	1.414	0.324	0.479	0.028	0.041	33	42.841	14.504	1.253
T2001-2	June_01	0.80	1.753	2.196	0.071	0.089	0.006	0.008	124	17.709	0.717	0.061
	2001 Q2			**9.702**		**0.880**		**0.188**	**277**	**35.025**	**3.175**	**0.677**
T2001-3	July_01	0.78	1.902	2.435	0.254	0.325	0.020	0.026	125	19.478	2.601	0.205
T2001-4	August_01	0.69	1.693	2.469	0.039	0.057	0.003	0.004	108	22.864	0.527	0.041
T2001-5	August_01	0.77	0.523	0.678	0.184	0.238	0.012	0.016	68	9.967	3.507	0.229
T2001-6	Sept_01	0.75	0.830	1.111	0.068	0.091	0.004	0.005	47	23.635	1.936	0.114
	2001 Q3			**6.693**		**0.711**		**0.051**	**348**	**19.232**	**2.045**	**0.146**
T2001-7	Nov_01	0.68	0.005	0.007	0.071	0.104	0.061	0.089	16	0.458	6.501	5.586
T2001-8	Dec_01	0.78	0.045	0.058	0.147	0.188	0.042	0.054	33	1.743	5.694	1.627
	2001 Q4			**0.065**		**0.292**		**0.143**	**49**	**1.323**	**5.958**	**2.920**
T2002-1	Feb_02	0.73	0.219	0.300	0.195	0.267	0.084	0.115	43	6.971	6.207	2.674
T2002-2	Mar_02	0.75	0.711	0.943	0.195	0.259	0.025	0.033	39	24.176	6.630	0.850
	2002 Q1			**1.243**		**0.525**		**0.148**	**82**	**15.153**	**6.408**	**1.806**
T2004-1	Aug-Sep'04	0.50	1.395	2.797	0.432	0.866	0.167	0.335	265	2.797	3.269	1.264
T2004-2	Sep-Oct'04	0.51	0.298	0.581	0.050	0.097	0.047	0.092	105	0.581	0.928	0.872
	2004 Q3			**3.378**		**0.964**		**0.426**	**370**	**9.129**	**2.604**	**1.152**
T2004-3	Oct '04	0.50	0.063	0.125	0.009	0.018	0.021	0.042	74	1.692	0.242	0.564
T2004-4	Nov-Dec'04	0.52	0.352	0.675	1.303	2.498	1.138	2.182	334	2.021	7.480	6.532
T2004-5	Dec '04	0.51	0.209	0.410	0.124	0.242	0.056	0.110	191	2.145	1.267	0.577
	2004 Q4			**1.210**		**2.758**		**2.334**	**599**	**2.020**	**4.604**	**3.896**

[1]April 2002 trip pooled with quarter 2 trips in 2001 to increase sample size.

Table 3. Discards from the Canadian scallop fishery on Georges Bank from 1996 to 2004.

			Yellowtail Flounder			Cod			Haddock		
	Quarter	Effort (hr)	Discard Rate (kg/hr)	Quarterly Discards (mt)	Annual Discards (mt)	Discard Rate (kg/hr)	Quarterly Discards (mt)	Annual Discards (mt)	Discard Rate (kg/hr)	Quarterly Discards (mt)	Annual Discards (mt)
1996	Q1	7735	8.653	67		2.737	21		2.553	20	
	Q2	11381	20.001	228		1.356	15		0.957	11	
	Q3	8495	10.297	87		1.054	9		0.598	5	
	Q4	4286	1.441	6	388	2.364	10	56	3.735	16	52
1997	Q1	5086	9.736	50		2.644	13		2.511	13	
	Q2	11636	22.504	262		1.310	15		0.941	11	
	Q3	9802	11.586	114		1.018	10		0.588	6	
	Q4	8311	1.622	13	438	2.284	19	58	3.673	31	60
1998	Q1	9713	10.819	105		2.552	25		2.468	24	
	Q2	16245	25.008	406		1.264	21		0.925	15	
	Q3	13155	12.874	169		0.983	13		0.578	8	
	Q4	15306	1.802	28	708	2.204	34	92	3.611	55	102
1999	Q1	10327	12.264	127		3.837	40		2.248	23	
	Q2	13087	28.347	371		1.901	25		0.842	11	
	Q3	6309	14.594	92		1.478	9		0.526	3	
	Q4	3351	2.043	7	597	3.314	11	85	3.288	11	49
2000	Q1	3492	13.709	48		5.123	18		2.027	7	
	Q2	7992	31.686	253		2.538	20		0.760	6	
	Q3	6381	16.313	104		1.973	13		0.475	3	
	Q4	4160	2.283	9	415	4.424	18	69	2.966	12	29
2001	Q1	7453	15.153	113		6.408	48		1.806	13	
	Q2	14415	35.025	505		3.175	46		0.677	10	
	Q3	9909	19.232	191		2.045	20		0.146	1	
	Q4	4882	1.323	6	815	5.958	29	143	2.920	14	39
2002	Q1	3311	15.153	50		6.408	21		1.806	6	
	Q2	9878	35.025	346		3.175	31		0.677	7	
	Q3	4610	18.032	83		2.468	11		0.423	2	
	Q4	5392	2.524	14	493	5.534	30	94	2.643	14	29
2003	Q1	7797	12.526	98		6.228	49		2.799	22	
	Q2	15645	28.954	453		3.086	48		1.049	16	
	Q3	15647	14.906	233		2.398	38		0.656	10	
	Q4	12188	2.086	25	809	5.378	66	200	4.095	50	98
2004	Q1	5267	9.899	52		6.047	32		3.792	20	
	Q2	11070	22.882	253		2.996	33		1.421	16	
	Q3	10235	9.129	93		2.604	27		1.152	12	
	Q4	11678	2.020	24	422	4.604	54	145	3.896	45	93

Table 4. Ratios for determining discards in 1969-1995.

Trip ID	Date	Effort (hr)	Proration	Observed Discards (mt)	Prorated Discards (mt)	Observed Kept (mt)	Prorated Kept (mt)	Landed (mt)	Landed Scallop (mt)
				Yellowtail Flounder					
T1991-1	Jan '91	348	0.50	2.568	5.086	0	0	0	167.896
T1994-1	Mar '94	138	0.84	0.060	0.071	0.363		1.738	127.501
T1994-2	Mar '94	127	0.77	0.001	0.001	0.060	0.078	0	114.237
T1994-3	Mar '94	106	0.71	0.219	0.311	0.024	0.034	0	69.013
T1995-1	Jan '95	143	0.23	0.079	0.338	0.006	0.026	0	60.867
T1995-2	Mar '95	120	0.09	0.04	0.447	0	0	0	49.440
T1995-3	Mar '95	127	0.16	0.199	1.230	0.028		0.3	71.430
Total		**1109**			**7.484**		**0.138**[1]	**2.038**	**660.384**
Ratio		**6.873**[2]						**3.740**	**0.0115**
				Cod					
T1991-1	Jan '91	348	0.50	0.267	0.529	0.037	0.073	0	167.896
T1994-1	Mar '94	138	0.84	0.003	0.004	0.154		0.341	127.501
T1994-2	Mar '94	127	0.77	0	0	0.136		0.531	114.237
T1994-3	Mar '94	106	0.71	0.051	0.072	0.025	0.035	0	69.013
T1995-1	Jan '95	143	0.23	0.034	0.145	0.055		0.090	60.867
T1995-2	Mar '95	120	0.09	0.029	0.324	0.023		0.176	49.440
T1995-3	Mar '95	127	0.16	0.010	0.062	0.075		0.690	71.430
T1995-4	Mar '95	164	0.56	0	0	0.045		0.407	78.243
Total		**1273**			**1.136**		**0.109**[1]	**1.828**	**660.384**
Ratio		**0.978**[2]						**0.681**	**0.0019**
				Haddock					
T1991-1	Jan '91	348	0.50	0.007	0.014	0.687	1.361	0	167.896
T1994-1	Mar '94	138	0.84	0	0	0.050		0.033	127.501
T1994-2	Mar '94	127	0.77	0	0	0.068	0.089	0	114.237
T1994-3	Mar '94	106	0.71	0.005	0.007	0.074	0.105	0	69.013
T1995-1	Jan '95	143	0.23	0.024	0.103	0.074	0.316	0	60.867
T1995-2	Mar '95	120	0.09	0.005	0.056	0.000	0	0	49.440
T1995-3	Mar '95	127	0.16	0.005	0.031	0.122		0.460	71.430
T1995-4	Mar '95	164	0.56	0	0	0.099	0.178	0	78.243
Total		**1273**			**0.210**		**2.049**[1]	**0.493**	**660.384**
Ratio		**1.774**[2]						**4.582**	**0.0034**

[1]Kept but not landed.
[2]Kg/hour.

Table 5. Summary of discard estimates (mt) from the Canadian Georges Bank scallop fishery. (Scallop landings are from NAFO records.)

Year	Effort (h)	Landings				Yellowtail flounder discards prorating by			Cod discards prorating by			Haddock discards prorating by		
		Scallop	Ytl	Cod	Had	Effort	Scallop	Land	Effort	Scallop	Landings	Effort	Scallop	Land
1960		28179					324			53			96	
1961		37889					436			71			130	
1962		47434					545			89			162	
1963		48957					563			92			167	
1964		49156					565			93			168	
1965		36803					423			69			126	
1966		40489					466			76			138	
1967		41657					479			78			142	
1968		40005	4	24	11		460	13		75	16		137	51
1969		35836	28	32	15		412	103		68	22		123	67
1970		34006	11	20	2		391	41		64	13		116	11
1971		32434	18	39	3		373	68		61	27		111	12
1972	75000	34535	5	29	1	515	397	17	73	65	20	133	118	3
1973	55000	35055	2	22	0	378	403	7	54	66	15	98	120	2
1974	90000	50934	2	2	1	619	586	7	88	96	1	160	174	6
1975	105000	61536	0	1	0	722	708	0	103	116	1	186	210	1
1976	90000	81017	0	0	0	619	932	0	88	153	0	160	277	0
1977	85000	108639	0	1	1	584	1249	1	83	205	1	151	372	5
1978	100000	101170	3	5	17	687	1163	13	98	191	3	177	346	78
1979	105000	76423	4	4	2	722	879	16	103	144	3	186	261	11
1980	85000	43334	7	7	4	584	498	27	83	82	5	151	148	17
1981	100000	66511	1	1	1	687	765	2	98	125	1	177	228	5
1982	73000	35744	0	0	0	502	411	0	71	67	0	130	122	0
1983	67000	22808	0	7	1	460	262	0	65	43	5	119	78	3
1984	70000	16144	3	9	2	481	186	10	68	30	6	124	55	7
1985	105000	31641	0	25	2	722	364	0	103	60	17	186	108	10
1986	52000	38759	15	16	4	357	446	55	51	73	11	92	133	17
1987	78000	56378	55	88	38	536	648	206	76	106	60	138	193	174
1988	85000	35993	42	73	16	584	414	155	83	68	50	151	123	75
1989	78000	38810	18	106	12	536	446	67	76	73	72	138	133	56
1990	72000	43312	9	64	7	495	498	32	70	82	44	128	148	31
1991	66000	48141	47	73	8	454	554	177	65	91	50	117	165	37
1992	73000	51055	36	102	4	502	587	135	71	96	69	130	175	18
1993	64000	51355	40	64	2	440	591	151	63	97	43	114	176	10
1994	64000	41528	21	63	9	440	478	78	63	78	43	114	142	39
1995	39000	16469	22	35	7	268	189	83	38	31	24	69	56	32
1996	31898	24865	0	0	0	388			56			52		
1997	34835	35332	0	0	0	438			58			60		
1998	54419	33127	0	0	0	708			92			102		
1999	33074	30702	0	0	0	597			85			49		
2000	22025	56545	0	0	0	415			69			29		
2001	36660	57057	0	0	0	815			143			39		
2002	23191	55291	0	0	0	493			94			29		
2003	51277	51423	0	0	0	809			200			98		
2004	38250	30856	0	0	0	422			145			93		

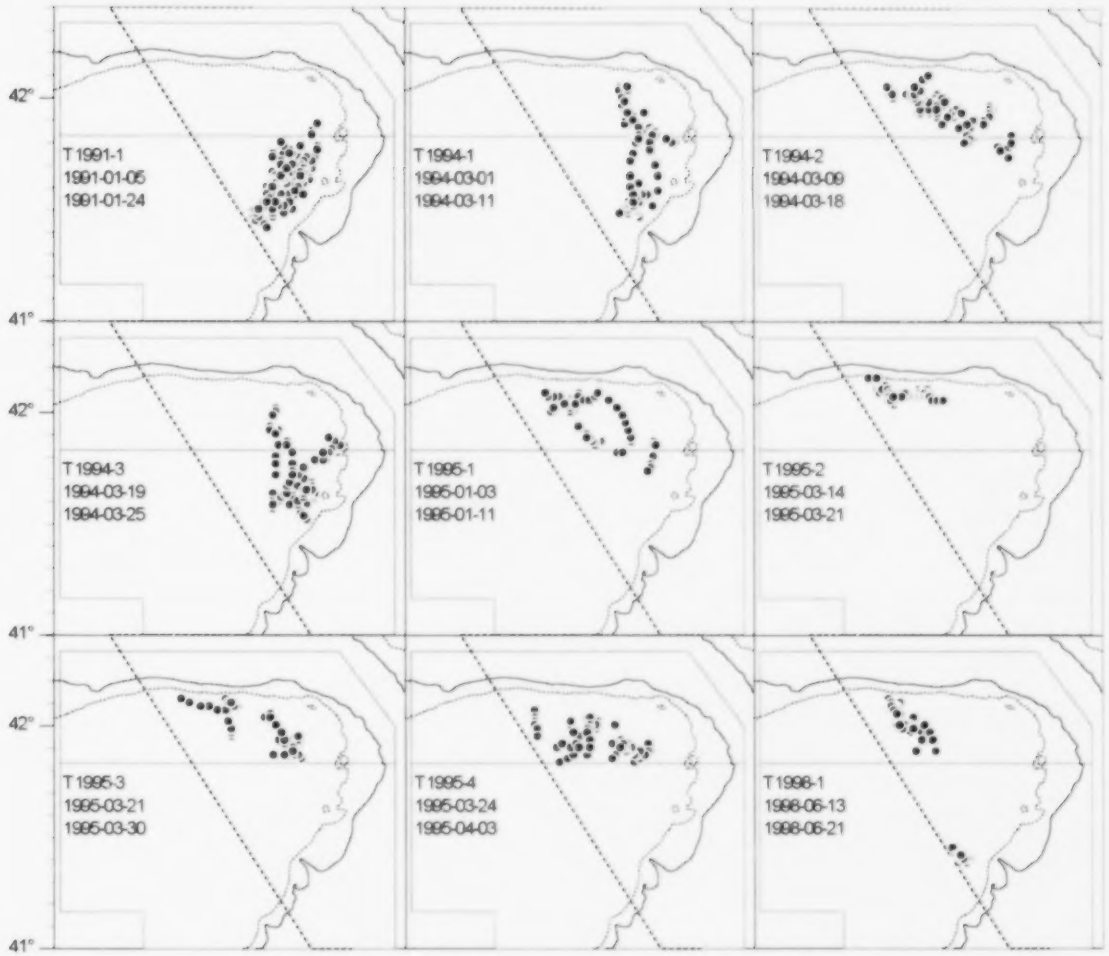

Figure 1. Geographic distribution of Georges Bank scallop fishery trips which had observer coverage in 1991, 1994, 1995 and 1998. These were often industry initiated trips to evaluate modifications to standard scallop gear. The dates refer to the first and last day of scallop fishing.

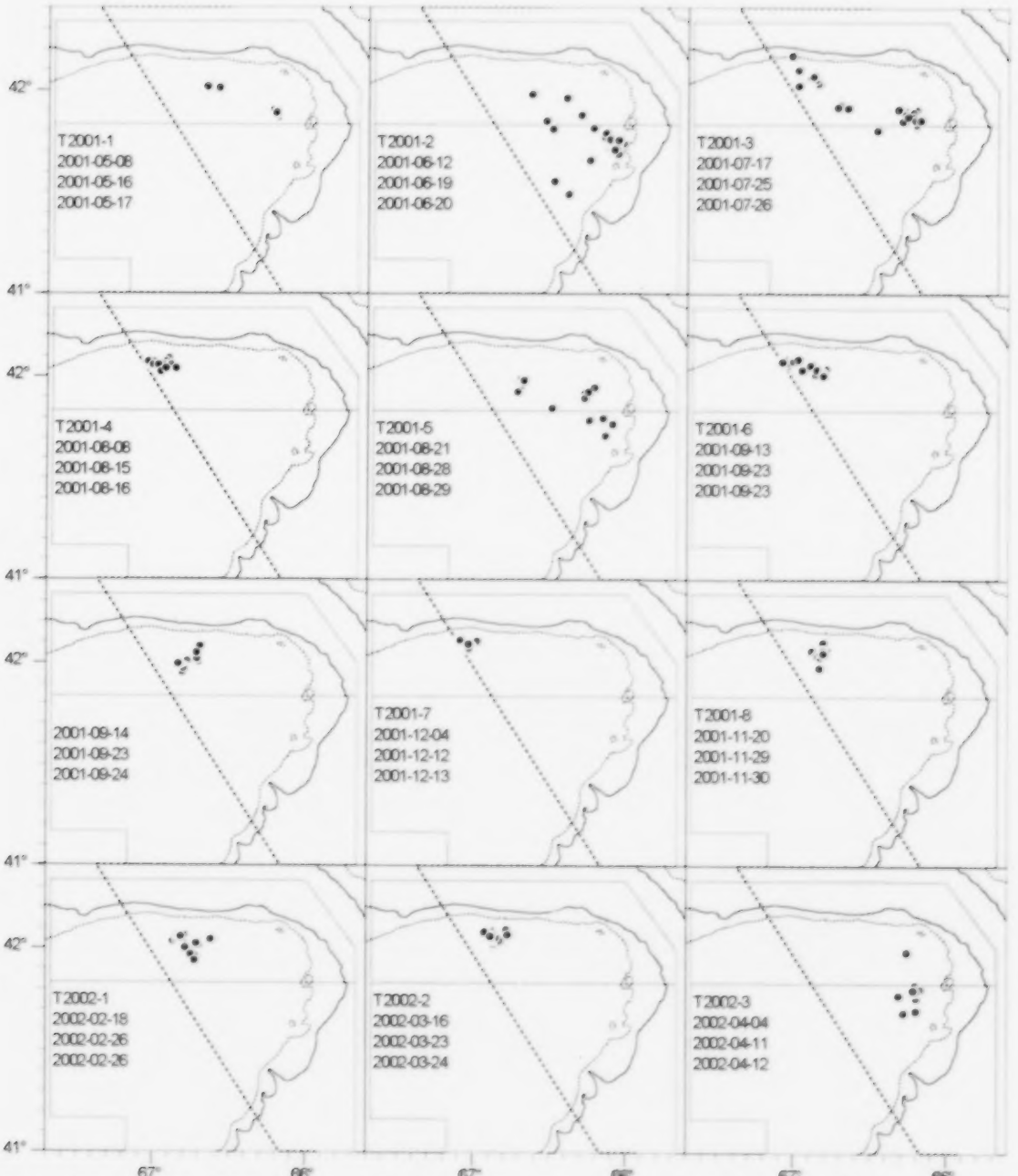

Figure 2. Geographic distribution of scallop fishery trips monitored as part of a Canadian Georges Bank offshore scallop industry program to gather data on by-catches of selected groundfish in 2001 and 2002. The dates refer to the first and last day of scallop fishing and the landed date. The trip landed Sept. 24, 2001 was excluded from the analysis as effort data was unavailable.

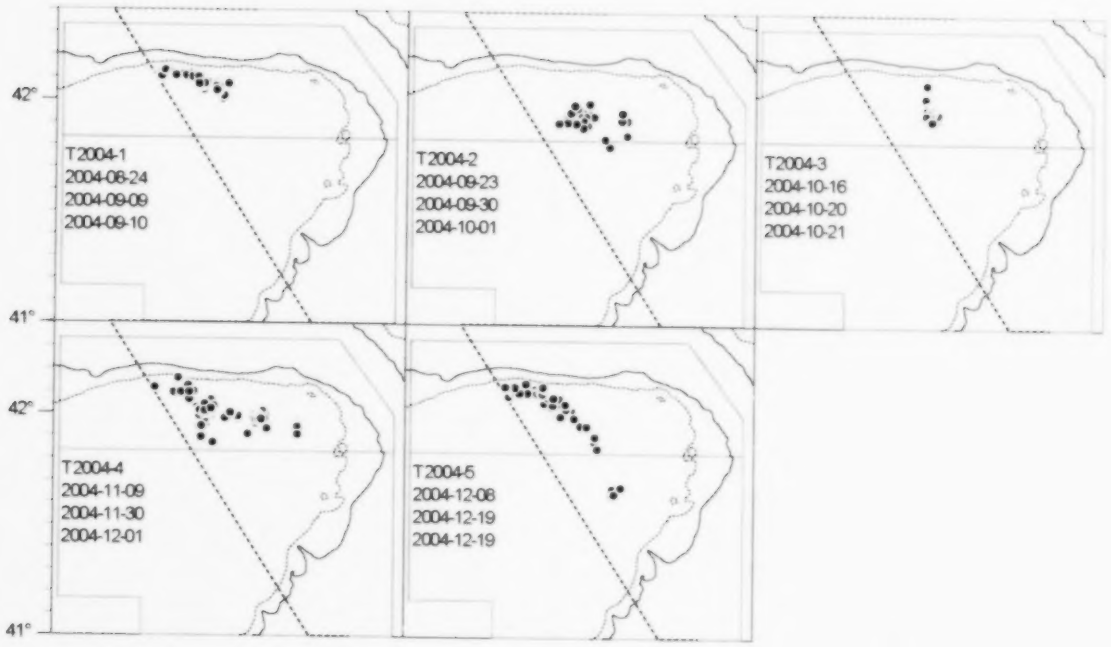

Figure 3. Geographic distribution of Georges Bank scallop fishery trips monitored as part of routine observer deployment initiated in August 2004. The dates refer to the first and last day of scallop fishing and the landed date.

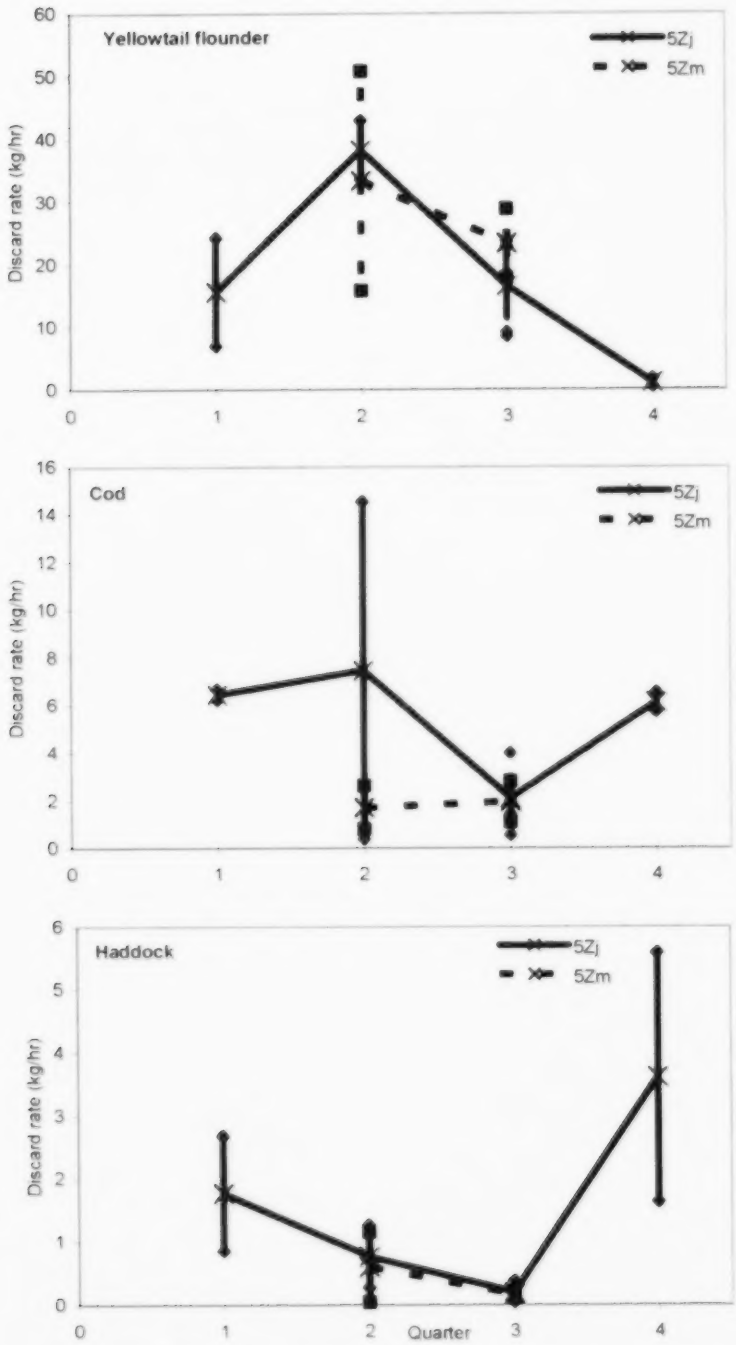

Figure 4. Quarterly discard rates (▽2 SE) for yellowtail flounder, cod and haddock from 12 observed Canadian scallop fishery trips on Georges Bank in 2001 and 2002.

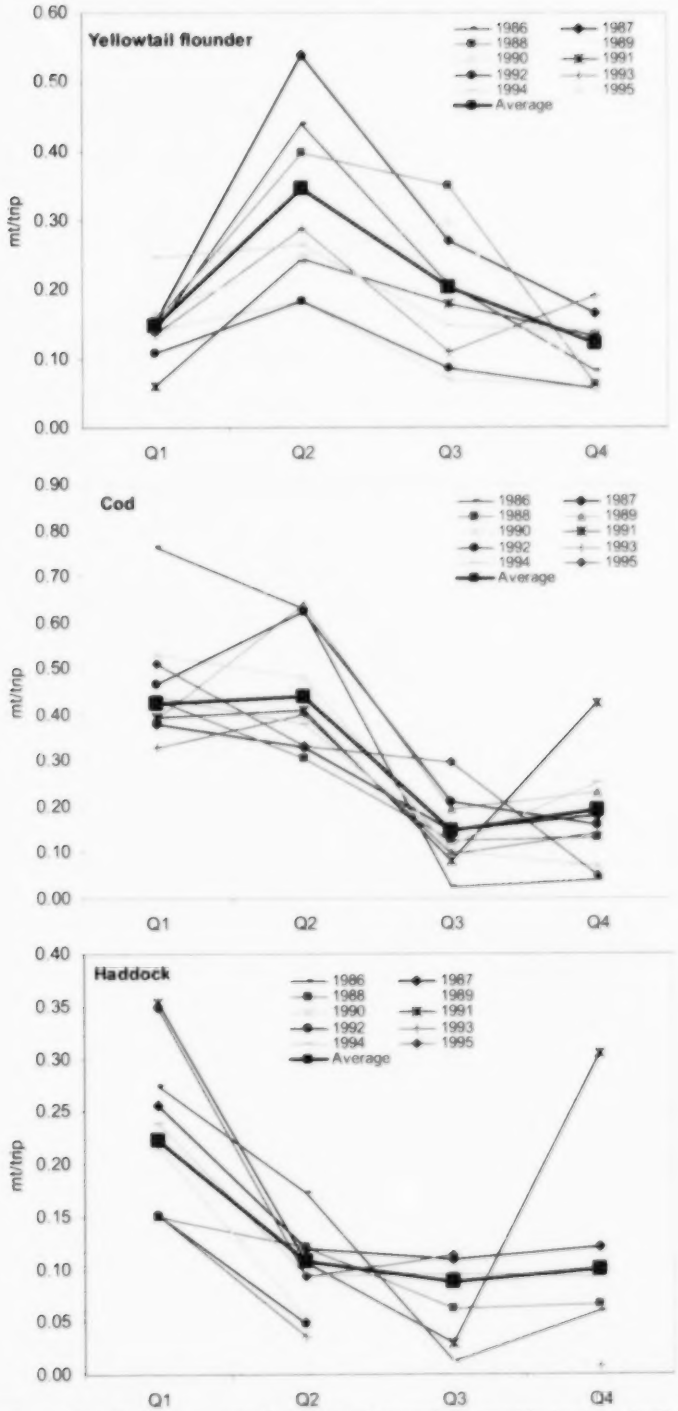

Figure 5. Georges Bank scallop fishery quarterly by-catch trends in metric tonnes (mt) per trip by year from reported landings for 1986 to 1995. Only trips that reported landings for the by-catch species were used.

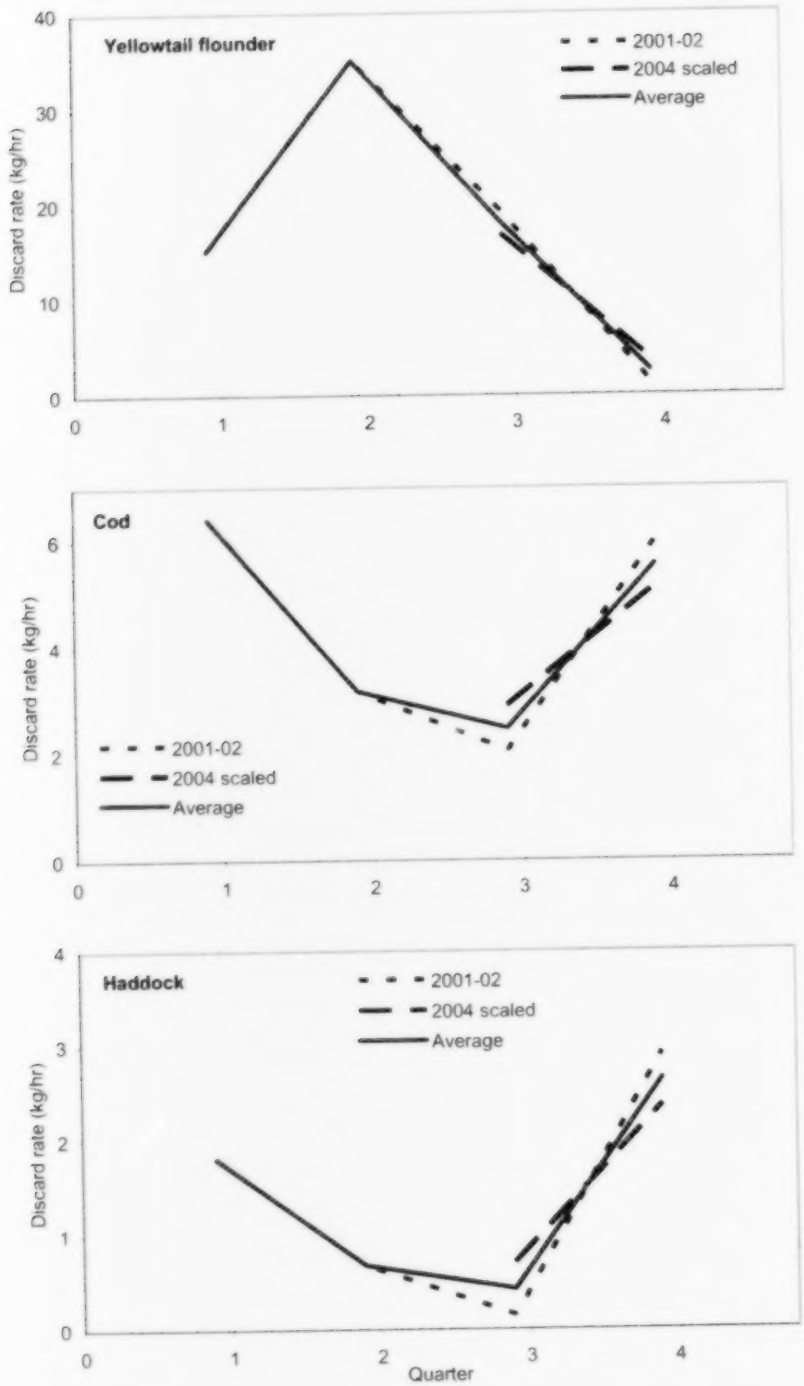

Figure 6. Quarterly discard rate patterns for yellowtail flounder, cod and haddock from observed trips in 2001-2002 and 2004 were averaged to derive seasonal factors.

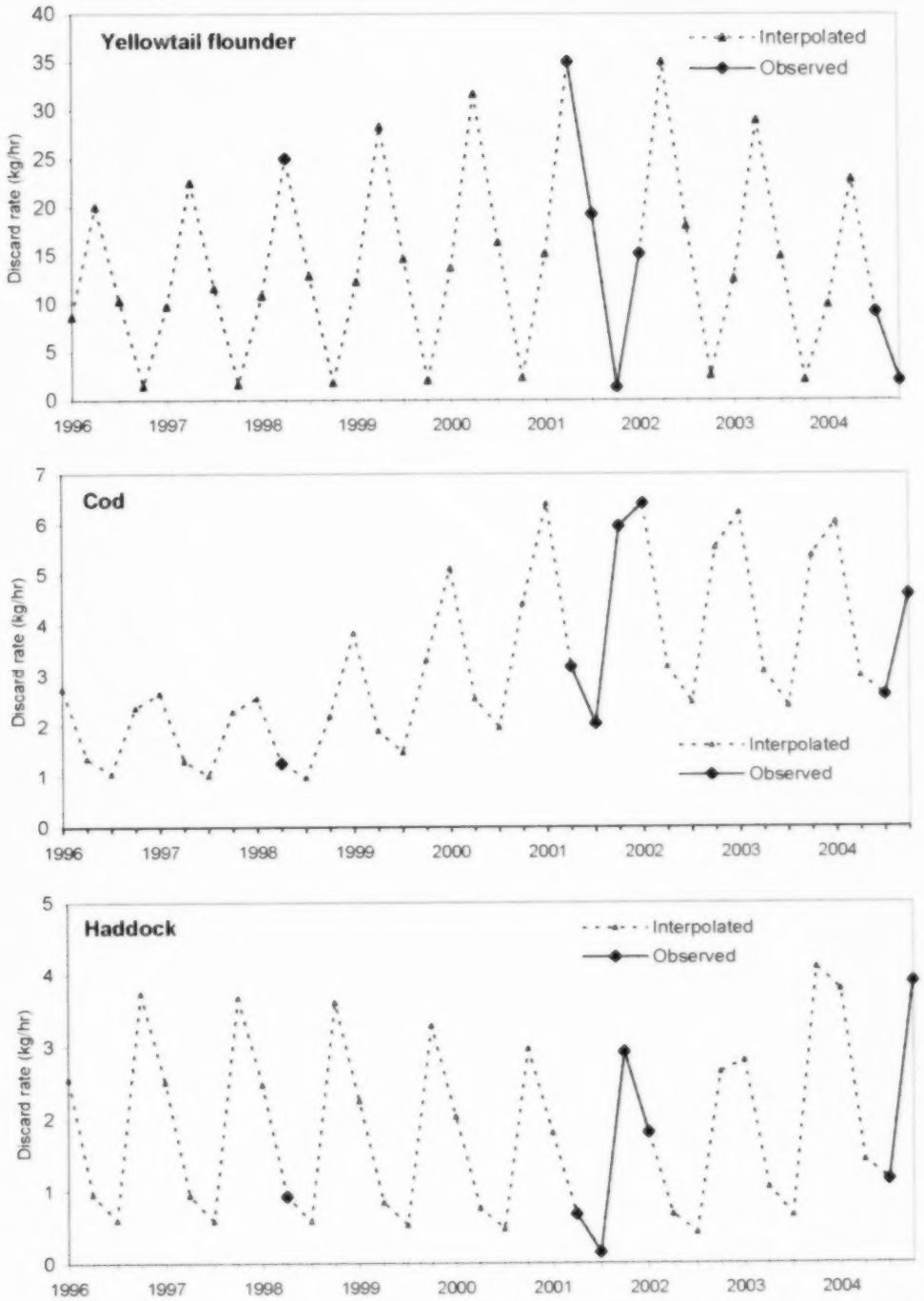

Figure 7. Quarterly discard rates from observed and interpolated values for yellowtail flounder, cod and haddock for 1996 to 2004.